PRELIMINARY SURVEY REPORT:

PRE-INTERVENTION QUANTITATIVE RISK FACTOR ANALYSIS

FOR SHIP CONSTRUCTION PROCESSES

AT

HALTER MOSS POINT SHIPYARD, MOSS POINT, MISSISSIPPI

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Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway, Mailstop R-5
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PLANT SURVEYED: Halter Moss Point Shipyard, Halter Marine Group, Inc. in Moss Point, Mississippi.

SIC CODE: 3731

SURVEY DATE: November 29-30, 1999

SURVEY CONDUCTED BY: Stephen D. Hudock, Steven J. Wurzelbacher.

EMPLOYER REPRESENTATIVES CONTACTED: Mike Davis, Corporate Safety Director (504-248-2236); Bobby Howell, Plant Manager, Halter Moss Point Shipyard; Bill Williams, Process Improvement Team (228-474-5830); Jake Winstead, ABC Process Improvement Team -- Corporate (228-493-6053); Emerald Smith, Safety Manager, Moss Point Division (228-475-1211); Bob Dearth, Safety/Environmental Manager (228-475-1211).

EMPLOYEE REPRESENTATIVES CONTACTED: Not applicable, non-union facility

ANALYTICAL WORK PERFORMED BY: No analytical work required by chemists.

DISCLAIMER

Mention of company names and/or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC).

ABSTRACT

A pre-intervention quantitative risk factor analysis was performed at various shops and locations within Halter Marine, Inc. Moss Point Shipyard as a method to identify and quantify risk factors that workers may be exposed to in the course of their normal work duties. This survey was conducted as part of a larger project, funded through Maritech Advanced Shipbuilding Enterprise and the U.S. Navy, to develop projects to enhance the commercial viability of domestic shipyards. Two operations were identified for further analysis: the gator bar worker in the steelyard and the shear press operation. The application of exposure assessment techniques provided a quantitative analysis of the risk factors associated with the individual tasks. Possible engineering interventions to address these risk factors for each task are briefly discussed.

I. INTRODUCTION

IA. BACKGROUND FOR CONTROL TECHNOLOGY STUDIES

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposures to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of the completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

IB. BACKGROUND FOR THIS STUDY

The domestic ship building, ship repair, and ship recycling industries have historically had much higher injury/illness incidence rates than those of general industry, manufacturing, or construction. For 1998, the last year available, the Bureau of Labor Statistics reported that shipbuilding and repair (SIC 3731) had a recordable injury/illness incidence rate of 22.4 per 100 full-time employees (FTE), up from 21.4 in 1997. By contrast, in 1998, the manufacturing sector reported a rate of 9.7 per 100 FTE, construction reported a rate of 8.8 per 100 FTE, and all industries reported a rate of 6.7 injuries/illnesses per 100 FTE. When considering only lost workday cases, for 1998, shipbuilding and repair had an incidence rate of 11.5 per 100 FTE, compared to manufacturing at 4.7, construction at 4.0, and all industries at 3.1 lost workday injuries/illnesses per 100 FTE.

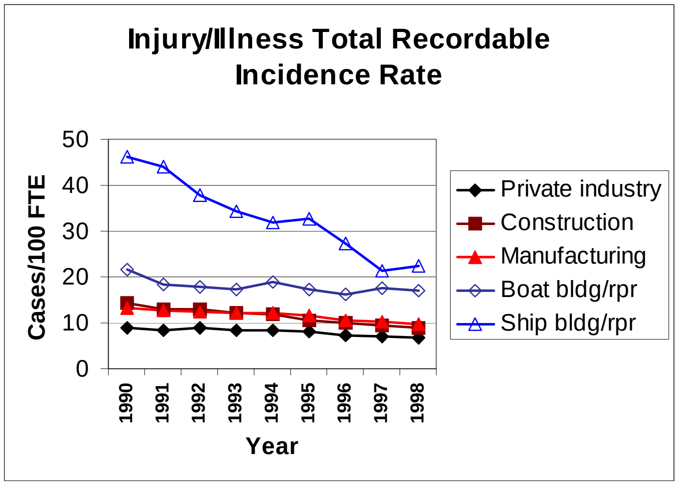

Figure 1. Injury/Illness Total Recordable Incidence Rate

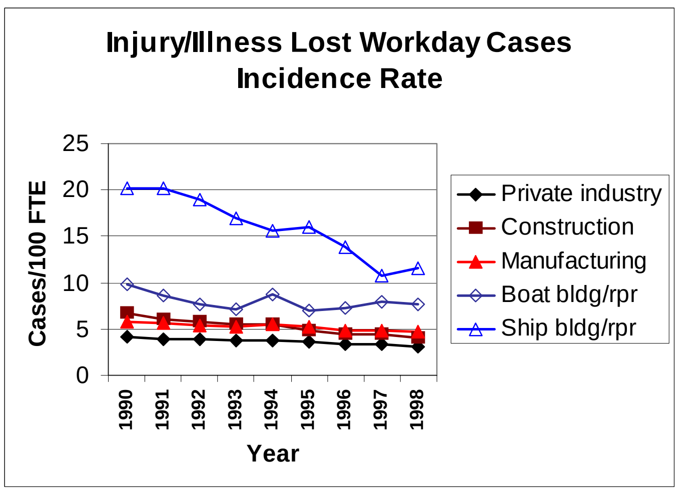

Figure 2. Injury/Illness Lost Workday Cases Incidence Rate

When comparing shipbuilding and repairing to the manufacturing sector for injuries and illnesses to specific parts of the body resulting in days away from work, for the year 1997, shipbuilding is significantly higher in a number of instances. For injuries and illnesses to the trunk including the back and shoulder, shipbuilding reported an incidence rate of 207.7 cases per 10,000 FTE, compared to manufacturing at 82.1 cases. For injuries and illnesses solely to the back, shipbuilding reported 111.1 cases per 10,000 FTE, compared to manufacturing's incidence rate of 52.2 cases. For the lower extremity, shipbuilding reported 145.0 cases per 10,000 FTE compared to manufacturing at 40.8 cases. For upper extremity injuries and illnesses, shipbuilding reported an incidence rate of 92.2 cases per 10,000 FTE while manufacturing reported 73.4 cases.

When comparing shipbuilding and repairing to the manufacturing sector for injuries and illnesses resulting in days away from work, for the year 1997, by nature of injury, shipbuilding is significantly higher in a number of categories. For sprains and strains, shipbuilding reported an incidence rate of 237.9 cases per 10,000 FTE, compared to manufacturing's incidence rate of 91.0 cases. For fractures, shipbuilding reported 41.7 cases per 10,000 FTE, compared to manufacturing at 15.8 cases. For bruises, shipbuilding reported 61.3 cases per 10,000 FTE, compared to manufacturing at 21.5 cases. The median number of days away from work for shipbuilding and repairing is 12 days, compared to manufacturing and private industry's median of 5 days.

Beginning in 1995 the National Shipbuilding Research Program began funding a project looking at the implementation of ergonomic interventions at a domestic shipyard as a way to reduce Workers' Compensation costs and to improve productivity for targeted processes. That project came to the attention of the Maritime Advisory Committee for Occupational Safety and Health (MACOSH), a standing advisory committee to the Occupational Safety and Health Administration (OSHA). The National Institute for Occupational Safety and Health (NIOSH) began an internally funded project in 1997 looking at ergonomic interventions in new ship construction facilities. In 1998, the U.S. Navy decided to fund a number of research projects looking to improve the commercial viability of domestic shipyards, including projects developing ergonomic interventions for various shipyard tasks or processes. Project personnel within NIOSH successfully competed in the project selection process. The Institute currently receives external project funding from the U.S. Navy through an organization called Maritech Advanced Shipbuilding Enterprise, a consortium of major domestic shipyards.

Shipyards participating in this project will receive an analysis of their injury/illness data, will have at least one ergonomic intervention implemented at their facility, and will have access to a website documenting ergonomic solutions found throughout the domestic maritime industries. The implementation of ergonomic interventions in other industries has resulted in decreases in Workers' Compensation costs, and increases in productivity.

Researchers will identify seven participating shipyards and analyze individual shipyard recordable injury/illness databases by the end of November 1999. Ergonomic interventions will be implemented in each of the shipyards by the end of June 2000. Intervention follow-up analysis will be completed by the end of December 2000. A series of meetings and a workshop to document the ergonomic intervention program will be held by the end of March 2001.

IC. BACKGROUND FOR THIS SURVEY

Halter Marine, Inc. Moss Point Shipyard was selected for a number of reasons. It was decided that the project should look at a variety of yards based on product, processes and location. Halter Marine, Inc. is the "nation's leading commercial shipbuilder" and is one of the top builders in the world of mid-sized ocean going vessels. Halter Marine, Inc. has a number of shipyards along the Gulf Coast that differ in work process and product. Some of the halter yards focus on new construction , others on repair services. Some of the Halter yards specialize in oil rig construction, others in vessel construction. All of Halter's yards are considered to be medium- to small-size yards. Halter Marine, Inc. is a member of the Shipbuilders Council of America.

II PLANT AND PROCESS DESCRIPTION

IIA. INTRODUCTION

Plant Description: The Halter Moss Point shipyard is located in Moss Point, Mississippi. The facility consists of approximately 58 acres of property with 61,500 square feet of shops, offices and warehouses and 60,165 square feet of outside concrete construction platforms. The facility has six crawler cranes and six track mounted gantry cranes. The yard has the capacity to build vessels up to 400 foot length, 85 foot beam, 18 foot water depth, and 85 foot height. At the time of the site visit, three off-shore service vessels (OSV's) for the Gulf oil drilling industry were in various stages of construction. Also, a special-purpose vessel for the U.S. National Aeronautics and Space Administration is under construction. This vessel will be used for the recovery of the space shuttle rocket boosters after each launch of the shuttle.

Corporate Ties: Halter Marine, Inc., a company of Friede Goldman Halter.

Products: Halter Marine, Inc. produces offshore supply vessels for the oil drilling industry, ocean-going tank barges and tug boats, excursion and gaming vessels, oceanographic and hydrographic research ships, logistic support vessels, and various small military interdiction craft.

Age of Plant: Halter Marine Moss Point yard has been functioning as a shipyard since 1993.

Number of Employees, etc: The Moss Point shipyard, as of the date of the survey, had 416 full-time Halter employees and 174 contract workers on site. Prior to 1997, there were fewer than 50 contract workers within the yard. In 1998, a new contractor was hired and, in general, fills the less-skilled production positions. Average annual employment historically has been approximately 400 workers.

IIB. PROCESS DESCRIPTION

Steelyard – Steel is delivered to the facility by truck and is stored in an outside storage yard serviced by a mobile tracked cranes.

Surface Preparation – Steel plate and shaped steel are moved from the supply yard by crane into a surface preparation area. Steel is abrasive blasted to remove any rust or mill residue. A primer paint is applied which coats the steel with an inorganic zinc coating to inhibit rusting.

Plate Shop – Steel plate is cut to size using numerical control plasma cutting tables. Smaller shapes are cut with gas burners, cut to size at the shears or punched at the punch presses.

Subassembly – Steel shapes are pieced together and welded to form a variety of sub-assemblies. Smaller subassemblies are joined to create bigger units.

Final Assembly – The individual units of the ship are welded together to form the hull and house sections.

Outfitting – The installation of propulsion, electrical , HVAC and other systems is begun after sub-assembly and continues until after the vessel is launched.

Painting – Vessels are painted to customer specifications prior to launch.

IIC. POTENTIAL HAZARDS

Major Hazards: Awkward postures, manual material handling, confined space entry, welding fumes, UV radiation from welding, paint fumes.

III. METHODOLOGY

A variety of exposure assessment techniques were implemented where deemed appropriate to the job task being analyzed. The techniques used for analysis include: 1) the Rapid Upper Limb Assessment (RULA); 2) the Strain Index; 3) a University of Michigan Checklist for Upper Extremity Cumulative Trauma Disorders; 4) the OVAKO Work Analysis System (OWAS); 5) a Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling; 6) the NIOSH Lifting Equation; 7) the University of Michigan 3D Static Strength Prediction Model; and 8) the PLIBEL method.

The Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993) is a survey method developed to assess the exposure of workers to risk factors associated with work-related upper limb disorders. On using RULA, the investigator identifies the posture of the upper and lower arm, neck, trunk and legs. Considering muscle use and the force or load involved, the investigator identifies intermediate scores which are cross-tabulated to determine the final RULA score. This final score identifies the level of action recommended to address the job task under consideration.

The Strain Index (Moore and Garg, 1995) provides a semiquantitative job analysis methodology that appears to accurately identify jobs associated with distal upper extremity disorders versus other jobs. The Strain Index is based on ratings of: intensity of exertion, duration of exertion, efforts per minute, hand and wrist posture, speed of work, and duration per day. Each of these ratings is translated into a multiplier. These multipliers are combined to create a single Strain Index score.

The University of Michigan Checklist for Upper Extremity Cumulative Trauma Disorders (Lifshitz and Armstrong, 1986) allows the investigator to survey a job task with regard to the physical stress and the forces involved, the upper limb posture, the suitability of the workstation and tools used, and the repetitiveness of a job task. Negative answers are indicative of conditions that are associated with the development of cumulative trauma disorders.

The OVAKO Work Analysis System (OWAS) (Louhevaara and Suurnäkki, 1992) was developed to assess the quality of postures taken in relation to manual materials handling tasks. Workers are observed repeatedly over the course of the day and postures and forces involved are documented. Work postures and forces involved are cross-tabulated to determine an action category which recommends if, or when, corrective measures should be taken.

The NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling (Waters and Putz-Anderson, 1996) is an example of a simple checklist that can be used as a screening tool to provide a quick determination as to whether or not a particular job task is comprised of conditions that place the worker at risk of developing low back pain.

The NIOSH Lifting Equation (Waters et al, 1993) provides an empirical method to compute the recommended weight limit for manual lifting tasks. The revised equation provides methods for evaluating asymmetrical lifting tasks and less than optimal hand to object coupling. The equation allows the evaluation of a greater range of work durations and lifting frequencies. The equation also accommodates the analysis of multiple lifting tasks. The Lifting Index, the ratio of load lifted to the recommended weight limit, provides a simple means to compare different lifting tasks.

The University of Michigan 3D Static Strength Prediction Program (University of Michigan, 1997) is a useful job design and evaluation tool for the analysis of slow movements used in heavy materials handling tasks. Such tasks can best be analyzed by describing the activity as a sequence of static postures. The program provides graphical representation of the worker postures and the materials handling task. Program output includes the estimated compression on the L5/S1 vetebral disc and the percentage of population capable of the task with respect to limits at the elbow, shoulder, torso, hip, knee and ankle.

The PLIBEL method (Kemmlert, 1995) is a checklist method that links questions concerning awkward work postures, work movements, design of tools and the workplace to specific body regions. In addition, any stressful environmental or organizational conditions should be noted. In general, the PLIBEL method was designed as a standardized and practical assessment tool for the evaluation of ergonomic conditions in the workplace.

Two specific processes were identified for further analysis. These processes were: angle iron positioning by a gator bar worker in the steelyard and a shear press operation. Each of these processes are examined in greater detail below.

IIIA. Angle Iron Positioning by Gator Bar Worker in Steelyard

Figure 3. Gator Bar Worker in Steelyard

IIIA1. Gator Bar Process

Prior to use in any sub-assembly, the raw steel stock must be blasted to remove rust of other residual material on the surface of the steel. Angle irons are delivered to the spraying platform in bundles by a mobile crane. The angle irons are dropped onto the platform and are then positioned across the platform as necessary by the gator bar worker and helper.

Figure 4. Gator Bar Worker Positioning Angle Iron

Figure 5. Gator Bar Worker Flipping Angle Iron from Side with Gator Bar

Figure 6. Gator Bar Worker Flipping Angle Iron from End with Gator Bar

Angle irons are adjusted into place by the gator bar worker using their hands or gator pry bar to grip the angle irons.

IIIA2. Ergonomic Risk Factors for Gator Bar Worker in Steelyard

While positioning and flipping angle irons for abrasive blasting, the gator bar worker experiences a number of ergonomic risk factors. These risk factors include awkward postures such as extreme lumbar flexion, as well as excessive loads to low back and shoulders.

IIIA3. Ergonomic Analysis of Gator Bar Workers in Steelyard

Using several of the exposure assessment tools outlined above, an ergonomic analysis was performed for the gator bar worker positioning and flipping angle irons. A Rapid Upper Limb Assessment was conducted for the gator bar worker and the angle separation task (Table 1). Analyses of four sub-tasks with unique postures and a composite task analysis each resulted in a rating to "investigate and change immediately."

A Strain Index analysis was performed for the gator bar worker (Table 2) with the following results:

1) the Intensity of Exertion was rated as "Somewhat Hard" and given a multiplier score of 3 on a scale of 1 to 13
2) the Duration of the task was rated as 10 - 29 % of the task cycle, resulting in a multiplier of 1.0 on a scale of 0.5 to 3.0
3) the Efforts per Minute were noted to be between 9 and 14, resulting in a multiplier of 1.5 on a scale of 0.5 to 3.0
4) the Hand/Wrist posture was rated as "Bad," resulting in a multiplier of 2.0 on a scale of 1.0 to 3.0

5) the Speed of Work was rated as "Normal," resulting in a multiplier of 1.0 on a scale of 1.0 to 2.0
6) the Duration of Task per Day was rated to be between 1 and 2 hours, resulting in a multiplier of 0.50 on a scale of 0.25 to 1.50.

The multiplier values for each segment are multiplied together resulting in a final Strain Index (SI) score. For this task the SI score was 4.5. An SI score less than 5 is correlated to an incidence rate of about 2 distal upper extremity injuries per 100 FTE. Regardless of actual incidence rate, the Strain Index indicates that this task puts the worker at a slightly increased risk of developing a distal upper extremity injury.

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the gator bar worker task (Table 3), of the 21 possible responses, fourteen were negative and seven were positive. Negative responses are indicative of conditions associated with the risk of developing cumulative trauma disorders.

When the OWAS technique was applied to the gator bar worker task (Table 4), corrective measures were suggested for a number of specific sub-tasks including: grasping the angle iron with the gator bar and using the gator bar to flip the angle iron.

The PLIBEL checklist for the gator bar worker task (Table 5) reports a high percentage (~ 80 %) of risk factors present for the elbows, forearms, and hands, and a moderate percentage (~ 50 %) of risk factors present for the neck, shoulder, upper back, and lower back. Several environmental and organizational modifying factors are present as well.

IIIB. Shear Operator

Figure 7. Shear Operator Placing Steel Plate on Shear

IIIB1. Shear Process

The primary process for the shear operator is to cut steel plate to various dimensions as required for hulls and subassemblies. The particular process flow for the shear press is as follows:

1) raw plates are moved from pallets to the shear by jib crane that sits between stations
2) long plates are laid across an array of roller bearing supports to hold weight of plate while being sheared, and
3) cut plates are dropped at the back of the shear onto a sloped tray that reaches to ground level. Smaller pieces may not slide to the bottom of the tray and must be hooked and slid to the bottom by the shear operator,

Figure 8. Shear Operator Hooking Small Cut Pieces

4) cut plates are either manually lifted or lifted by jib crane and placed into containers.

Figure 9. Shear Operator Lifting Pieces at Back of Shear

Figure 10. Shear Operator Using Jib Crane to Lift Cut Plate

IIIB2. Ergonomic Risk Factors of Shear Operator

Shear operators often lift awkward loads from the ground-level shear chutes and material supply pallets. Contact stresses experienced by the shear operator include kneeling on the floor to get material and contact with the sharp edges of the raw or cut material.

IIIB3. Ergonomic Analysis of Shear Operator

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the shear operator task (Table 6), of the 21 possible responses, seven were negative, seven were positive, and seven were not applicable. Negative responses are indicative of conditions associated with the risk of developing cumulative trauma disorders.

The NIOSH checklist for manual materials handling consists of 14 items. When applied to the shear operator task (Table 7), five responses were positive and nine negative. In this checklist, positive responses are indicative of conditions that pose a risk to the worker of developing low back pain. The higher the percentage of positive response, the greater the risk of low back pain.

The NIOSH Lifting Equation was used to analyze the sub-task of manually picking material up from the back of the shear. The analysis (Table 8) for this task suggests a recommended weight limit of 12.4 pounds, given the assumed posture. Given that the typical weight of the plate is about 20 pounds, it is determined that 92 % of the male population and 41 % of the female population can perform this task without an increased risk of low back pain.

The University of Michigan 3D Static Strength Prediction Program was used to analyze the shear operator lifting a plate one-handed from the back of the shear machine (Table 9). Analysis of this sub-task resulted in an estimated disc compression loads at the L5/S1 disc to be 673 pounds, below the NIOSH Recommended Compression Limit of 770 pounds.

The PLIBEL checklist for the shear operator task (Table 10) reports a moderate percentage (between 40 and 50 %) of risk factors present for the neck, shoulder, upper back, and lower back. Several environmental and organizational modifying factors are present as well.

IV. CONTROL TECHNOLOGY

Possible interventions and control technologies are mentioned briefly here. A more detailed report of possible interventions is forthcoming.

IVA. Angle Iron Unload in Steelyard Possible Interventions

Changes in how the load is slung and/or handled by the crane may help in distributing the angle iron across the platform. A simple push mechanism on the unloading platform may eliminate the need for two workers to hook and pull long angle irons across the platform.

IVB. Shear Operation in Plate Shop Possible Interventions

The primary intervention for the shear operator is to provide adjustable lift tables for cut materials at the back of the shear machine in lieu of the sloped tray.

V. CONCLUSIONS AND RECOMMENDATIONS

Two work processes within a ship building operation were surveyed to determine the presence of risk factors associated with musculoskeletal disorders. The unloading of angle iron in the steelyard was analyzed using a number of exposure assessment techniques. The high amount of effort required to separate and flip individual pieces of long angle irons is a risk factor associated with this process. Possible interventions include using the mobile crane to spread the stack of angle irons across the paltform when dropped and automating some of the processes to eliminate the pulling of angle irons into position across the platform.

The shear operator often bends at the waist to pick up pieces of steel or to attach them to the jib crane. Manually lifting the pieces of steel from near floor level results in undue stress on the back of the workers. By incorporating lift tables or tilting pallet jacks into areas both in front and behind the shear machine one can minimize the stress on the workers' backs. Each of the interventions highlighted here for the two processes will be discussed in much greater detail in a forthcoming report.

It is recommended that further action be taken to mitigate the exposure to musculoskeletal risk factors within each of the identified tasks. The implementation of ergonomic interventions has been found to reduce the amount and severity of musculoskeletal disorders within the working population in various industries. It is recommended that ergonomic interventions may be implemented at Halter Marine Moss Point shipyard to minimize hazards in the identified job tasks.

VI. REFERENCES

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University of Michigan Software, *3D Static Strength Prediction Program Version 4.0*, 3003 State St., #2071 Ann Arbor, MI 48109-1280, Copyright 1997 The Regents of The University of Michigan.

APPENDIX

TABLES

A1. Gator Bar Worker

Table 1. Gator Bar Worker RULA

Rapid Upper Limb Assessment (RULA) (Matamney and Corlett, 1993)

Date/ Time 11/29/99 | Facility: Halter Marine Moss Point
Area/ Shop: Steelyard | Task : Angle iron positioning by gator bar worker

RULA Component	Frame # 15990		Frame # 16170		Frame # 16470		Frame # 17190		Composite	
	Specific	*RULA Score*	*Specific*	*RULA Score*	*Specific*	*RULA Score*	*Specific*	*RULA Score*	*Specific*	*RULA Score*
Shoulder Extension/ Flexion	sl flex	2	ext	2	ext	2	mod flex	3	sl flex (44%)	2
Shoulder is Raised (+1)		0		1		1		0		0
Upper Arm Abducted (+1)		0		1		1		0		0
Arm supported, leaning (-1)		0		0		0		0		0
Elbow Extension/ Flexion	ext	1	neut	2	flex	2	ext	1	ext (60%)	1
Shoulder Abduction/ Adduction	neut	0	m abd	1	hyp abd	1	add	1	neut (65%)	0
Shoulder Lateral/ Medial	neut	0	lat	1	lat	1	m med	1	neut (69%)	0
Wrist Extension/ Flexion	ext	2	ext	2	flx	2	ext	2	ext (44%)	2
Wrist Deviation	rad	1	rad	1	ulnar	1	ulnar	1	ulnar or rad (62%)	1
Wrist Bent from Midline (+1)		0		0		0		0		0
Wrist Twist (1) In mid range Or (2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		1
Arm and Wrist Force/ load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		2

Neck Extension/ Flexion		2		2		2		2		2
Neck Twist (+1)		0		1		0		0		0
Neck Side-Bent (+1)		0		1		0		0		0
Trunk Extension/ Flexion	mod flex	3	sl flex	2	sl flex	2	hyp flex	4	sl flex (35%)	2
Trunk Twist (+1)		1		0		0		0		0
Trunk Side Bend (+1)		1		1		1		0		1
Legs If legs and feet are supported and balanced: (+1); If not: (+2)		1		1		2		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		1
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		2
Total RULA Score	**7**		**7**		**7**		**7**		**7**	
1 or 2 = ACCEPTABLE **3 or 4 = INVESTIGATE FURTHER** **5 or 6 = INVESTIGATE FURTHER AND CHANGE SOON** **7 = INVESTIGATE AND CHANGE IMMEDIATELY**										

Table 2. Gator Bar Worker Strain Index

STRAIN INDEX: DISTAL UPPER EXTREMITY (DUE) DISORDERS RISK ASSESSMENT
(Moore and Garg, 1995)

LOCATION: Halter Marine Moss Point Steelyard, 11/29/99
TASK: Angle iron positioning by gator bar worker

1. **Intensity of Exertion:** An estimate of the strength required to perform the task one time. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.					
Rating Criterion	***% MS*** (percentage of maximal strength)	***Borg Scale*** (Compare to Borg Cr-10 Scale)	***Perceived Effort***	***Rating*** (circle)	***Multiplier***
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1
Somewhat hard	**10 - 29%**	**3**	**noticeable or definite effort**	**2**	**3**
Hard	30 - 49%	4 - 5	obvious effort; unchanged facial expression (*28 -38% of observed time > = Hard)	3	6
Very Hard	50 - 79%	6 - 7	substantial effort; changes to facial expression	4	9
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13
				Intensity of Exertion Multiplier	**3**

Table 2 (continued). Gator Bar Worker Strain Index

2. **Duration of Exertion (% of cycle)**: Calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box.***NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0**			
Worksheet:	***Rating Criterion***	***Rating***	***Multiplier***
% Duration of Exertion = 100 x duration of all exertions (sec) / Total observation time (sec) = 100 x 546 (sec)/ 984 (sec) = 55	< 10	1	0.5
	10 - 29	**2**	**1.0**
	30 - 49	3	1.5
	50 -79	4	2.0
	> or = 80	5	3.0
Duration of Exertion Multiplier			**1.0**

3. **Efforts per Minute:** Measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. ***NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0**			
Worksheet:	***Rating Criterion***	***Rating***	***Multiplier***
Efforts per Minute = 100 x number of exertions / Total observation time (min) = 100 x [total # of efforts for observed period, 67/ Total observed time (min) 16.39] = 4.1	< 4	1	0.5
	4 - 8	2	1.0
	9 -14	**3**	**1.5**
	15 -19	4	2.0
	> or = 20	5	3.0
Efforts per Minute Multiplier (Fill in)			**1.5**

Table 2 (continued). Gator Bar Worker Strain Index

4. **Hand/ Wrist Posture:** An estimate of the position of the hand or wrist relative to neutral position. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.						
Rating Criterion	***Wrist Extension*** (Stetson et al, 1991)	***Wrist Flexion*** (Stetson et al, 1991	***Ulnar Deviation*** (Stetson et al, 1991	***Perceived Posture***	***Rating*** (circle)	***Multiplier***
Very Good	0 -10 degrees	0 - 5 degrees	0 - 10 degrees	perfectly neutral	1	1.0
Good	11 - 25 degrees	6 - 15 degrees	11 -15 degrees	near neutral	2	1.0
Fair	26 -40 degrees	16 - 30 degrees	16 - 20 degrees	non-neutral	3	1.5
Bad	**41 - 55 degrees**	**31 - 50 degrees**	**21 -25 degrees**	**marked deviation**	**4**	**2.0**
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
				Hand/ Wrist Posture Multiplier		**2.0**

Table 2 (continued). Gator Bar Worker Strain Index

5. **Speed of Work:** An estimate of how fast the worker is working. Circle the rating on the far right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.				
Rating Criterion	***Compared to MTM*** -1 (observed pace is divided by MTM's predicted pace and expressed as %)	***Perceived Speed***	***Rating*** (circle)	***Multiplier***
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81 - 90%	"taking one's own time"	2	1.0
Fair	**91 -100%**	**"normal" speed of motion**	**3**	**1.0**
Fast	101-115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed and barely or unable to keep up	5	2.0
			Speed of Work Multiplier	**1.0**

6. **Duration of Task per Day:** Either measured or obtained from plant personnel. Circle the rating on the right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.			
Worksheet:	***Rating Criterion***	***Rating*** (circle)	***Multiplier***
Duration of Task per Day (hrs)	< or = 1 hrs	1	0.25
= duration of task (hrs) + duration of task (hrs) + ...	**1 - 2 hrs**	**2**	**0.50**
	2 - 4 hrs	3	0.75
	4 - 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
		Duration of Task per Day Multiplier	**0.50**

Table 2 (continued). Gator Bar Worker Strain Index

Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion **3 x**	**Duration of Exertion** **1 x**	**Efforts per Minute** **1.5 x**	**Hand/ Wrist Posture** **2 x**	**Speed of Work** **1 x**	**Duration of Task** **.50**	**=**	**SI SCORE** **4.5**

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

– SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;

– SI Score of between 5-30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;

– SI Score of between 31-60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE;

– SI Score > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table 3. Gator Bar Worker UE CTD Checklist

Michigan Checklist for Upper Extremity Cumulative Trauma Disorders
(Lifshitz and Armstrong, 1986)

Date/ Time 11/29/99 — Facility Halter Marine Moss Point
Area/ Shop Steelyard — Task Gator Bar Worker
* "No" responses are indicative of conditions associated with the risk of CTD's

Risk Factors	**No**	**Yes**
1. **Physical Stress**		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?		Y
1.4 Can the job be done without using gloves?	N	
2. Force		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
3. Posture		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?		Y
4. Workstation Hardware		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
5. Repetitiveness		
5.1 Is the cycle time longer than 30 seconds?		Y
6. Tool Design		
6.1 Are the thumb and finger slightly overlapped in a closed grip?		Y
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?		Y
6.3 Is the handle of the tool made from material other than metal?	N	
6.4 Is the weight of the tool below 4 kg (9lbs)?	N (~12 lbs)	
6.5 Is the tool suspended?	N	
TOTAL	14 (67%)	7 (33%)

Table 4. Gator Bar Worker OWAS

OWAS: OVAKO Work Analysis System (Louhevaara and Suurnäkki, 1992)

Procedure: Observe workers at intervals of 30-60 seconds and record the postures and forces over a representative period (~ 45 minutes)

Date/ Time 11/29/99 Facility Halter Marine Moss Point
Area/ Shop: Steelyard Task: Angle iron positioning by gator bar worker

	Work Phase1: Grasp angle with jaw end (horizontal slot) of bar	**Work Phase 2 Flip angle over with bar (beginning)**	**Work Phase 3 Flip angle over with bar (middle)**	**Work Phase 4 Flip angle over with bar (end)**	**Work Phase 5 Reposition towards angles**
TOTAL Combination Posture Score	***2***	***4***	***1***	***3***	***1***
Common Posture Combinations (collapsed across work phases)					
Back	4	4	1	2	
Arms	2	1	1	1	
Legs	2	4	7	7	
Posture Repetition (% of working time)	7	2	7	6	
BACK % of Working Time SCORE	***1***	***1***	***1***	***1***	
ARMS % of Working Time SCORE	***1***	***1***	***1***	***1***	
LEGS % of Working Time SCORE	***1***	***1***	***1***	***1***	
ACTION CATEGORIES: ***1 = no corrective measures*** ***2 = corrective measures in the near future*** ***3 = corrective measures as soon as possible*** ***4 = corrective measures immediately***					

Risk Factor	**Work Phase1: Grasp angle with jaw end (hor-zontal slot) of bar**	**Work Phase 2 Flip angle over with bar (beginning)**	**Work Phase 3 Flip angle over with bar (middle)**	**Work Phase 4 Flip angle over with bar (end)**	**Work Phase 5 Reposition towards angles**
Posture					
Back 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	4	4	1	2	1
Arms 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	2	1	1	1	1
Legs 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2	4	7	7	7
Load/ Use of Force					
1 = weight or force needed is = or <10 kg 2 = weight or force > 10 but < 20kg 3 = weight or force > 20 kg	1	2	2	2	1
Phase Repetition					
% of working time (0,10,20,30,40,50,60,70,80,90,100)	07	02	02	06	05

Table 5. Gator Bar Worker PLIBEL

PLIBEL Checklist (Kemmlert, 1995)

Date/ Time: 11/29/99
Area/ Shop: Steelyard

Facility: Halter Marine Moss Point
Task: Angle iron positioning by gator bar worker

Section I: Musculoskeletal Risk Factors

Methods of Application:

1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)
2) Answer questions, score potential body regions for injury risk

Musculoskeletal Risk Factor Questions	*Body Regions*				
	Neck, Shoulder, Upper Back	**Elbows, Forearms, Hands**	**Feet**	**Knees and Hips**	**Low Back**
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	Y				Y

Table 5 (continued). Gator Bar Worker PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	N				N
b) weight of load	N				N
c) awkward grasping of load	N				N
d) awkward location of load at onset or end of lifting	N				N
e) handling beyond forearm length	Y				Y
f) handling below knee length	N				N
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		Y			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table 5 (continued). Gator Bar Worker PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	**Elbows, Forearms, Hands**	**Feet**	**Knees and Hips**	**Low Back**
SUM	15	9	3	3	11
PERCENTAGE	57.7	81.8	37.5	37.5	52.4
Section II: Environmental / Organizational Risk Factors (Modifying) Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	Y				
20: Is the job performed under time demands or psychological stress	N				
21:Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	N				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
Environmental / Organizational Risk Factors Score					
SUM	3				
PERCENTAGE	30.0				

A2. Shear Operator

Table 6. Shear Operator UE CTD Checklist

Michigan Checklist for Upper Extremity Cumulative Trauma Disorders

(Lifshitz and Armstrong, 1986)

Date/ Time 11/29/99 Facility Halter Marine Moss Point

Area/Shop: Plate shop Task Shear Operator

* "No" responses are indicative of conditions associated with the risk of CTD's

Risk Factors	No	Yes
1. Physical Stress		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker's hands exposed to temperature >21 degrees C (70 degrees F)?		Y
1.4 Can the job be done without using gloves?	N	
2. Force		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
3. Posture		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	n/a	n/a
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?		Y
4. Workstation Hardware		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	n/a	n/a
5. Repetitiveness		
5.1 Is the cycle time longer than 30 seconds?		Y
6. Tool Design		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	n/a	n/a
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?	n/a	n/a
6.3 Is the handle of the tool made from material other than metal?	n/a	n/a
6.4 Is the weight of the tool below 4 kg (9lbs)?	n/a	n/a
6.5 Is the tool suspended?	n/a	n/a
TOTAL	7 (50 %)	7 (50 %)

Table 7. Shear Operator NIOSH Manual Materials Handling Checklist

NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling
(Waters and Putz-Anderson, 1996)

Date/ Time 11/29/99 Facility Halter Marine Moss Point
Area/ Shop: Plate Shop Task Shear Press Operator

RISK FACTORS	YES	NO
General		
1.1 Does the load handled exceed 50 lbs?		N
1.2 Is the object difficult to bring close to the body because of it's size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	Y (ridges at shear press back)	
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extreme lumbar flexion)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?		N
1.9 Does the task require working in a confined area?		N
Specific		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N (LPM = 0.10 over total observed time of 10 minutes)
2.2 Does the vertical lifting distance exceed 3 feet?	Y	
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?		N
2.5 Do extended reach static holding tasks exceed 1 minute?		N
TOTAL	5 (36 %)	9 (64 %)

* "YES" responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of "YES" responses, the greater the risk.

Table 8. Shear Operator NIOSH Lifting Equation Analysis

NIOSH Lifting Equation (Waters, Putz-Anderson, Garg, and Fine, 1993)

Date/ Time 11/29/99
Area/ Shop: Plate Shop

Facility Halter Marine Moss Point
Task: Shear Operator Plate Lift from Back of Shear

Duration: 1 hour	**Average Object Weight: 20 pounds**	**Maximum Object Weight: 51 pounds**
ORIGIN VARIABLE	***ORIGIN VALUE***	***ORIGIN MULTIPLIER***
Horizontal Location, H	24 inches	0.42
Vertical Location, V	7 inches	0.83
Travel Distance, D	29 inches	0.89
Asymmetric Angle, A	40 degrees	0.87
Frequency, F	0.16 lifts/minute	1.00
Hand to Object Coupling, C	Poor	0.90
DESTINATION VARIABLE	***DESTINATION VALUE***	***DESTINATION MULTIPLIER***
Horizontal Location, H	10 inches	1.00
Vertical Location, V	31 inches	0.99
Travel Distance, D	29 inches	0.89
Asymmetric Angle, A	40 degrees	0.87
Frequency, F	0.16 lifts/minute	1.00
Hand to Object Coupling, C	Poor	0.90
RESULTS	***ORIGIN***	***DESTINATION***
Recommended Weight Limit (RWL)	12.4 pounds	35.2 pounds
Lifting Index, LI (RWL/Load)	1.61	
Population Capable	Male = 92 % Capable Female = 41 % Capable	

Table 9. Shear Operator 3D Static Strength Prediction Program

3D Static Strength Prediction Program (University of Michigan, 1997)

Date/ Time: 11/29/99
Area/ Shop: PlateShop

Facility: Halter Marine Moss Point
Task: Plate pick up from back of shear

Work Element: Shear Operation	**Disc Compression (lbs) @ L5/S1** (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)
One-handed pick-up of plate from back of shear. Plate weighs 20 lbs; lifts plate off shelf at back of tray, then drops plate into bin; 20 lbs in right hand	673 lbs. (middle of lift)

Table 10. Shear Operator PLIBEL

PLIBEL Checklist (Kemmlert, 1995)

Date/ Time: 11/29/99
Area/ Shop: Plate Shop

Facility: Halter Marine Moss Point
Task: Shear Operator

Section I: Musculoskeletal Risk Factors

Methods of Application:
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)
2) Answer questions, score potential body regions for injury risk

Musculoskeletal Risk Factor Questions	*Body Regions*				
	Neck, Shoulder, Upper Back	**Elbows, Forearms, Hands**	**Feet**	**Knees and Hips**	**Low Back**
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	N	N	N	N	N
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	N				N
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table 10 (continued). Shear Operator PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	N				N
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	N	N			N
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	N	N			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		N			
c) uncomfortable hand positions?		N			
d) switches or keyboards?		N			

Table 10 (continued). Shear Operator PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	**Elbows, Forearms, Hands**	**Feet**	**Knees and Hips**	**Low Back**
SUM	12	3	1	1	9
PERCENTAGE	46.2	27.3	12.5	12.5	42.9
Section II: Environmental / Organizational Risk Factors (Modifying) Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21:Can the work have unusual or expected situations?	Y				
22: Are the following present?					
a) cold	N				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
Environmental / Organizational Risk Factors Score					
SUM	3				
PERCENTAGE	30.0				